RESEARCH HIGHLIGHT
Basic Energy Sciences Program
Geosciences Subprogram

Title: Micromechanical Processes in Porous Geomaterials

PIs:

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Objective:

The goal of the research program is to enhance fundamental understanding of microscale processes, including failure and transport, in geologic materials and thereby strengthen the scientific basis for the application of laboratory results to technological efforts of current societal concern and impact. The project focuses on systematic investigation of the microscale characteristics of natural earth materials, and how these micro-scale characteristics control the macroscopic deformation and transport behavior.

Results:

Conventional imaging technologies, such as optical light microscopy and scanning electron microscopy, rely on the analysis of polished planar sections. However, a significant limitation of the conventional techniques is that they offer only a two-dimensional view of a three-dimensional structure, which greatly complicates, if not precludes, determination of the true three-dimensional structure. Previously, we described development of a new technique for imaging the pore space of geomaterials in three-dimensions using laser scanning confocal microscopy (Fredrich, Menéndez, and Wong, *Science*, 268, 276-279, 1995). This paper presents several examples of this application, including studying pore geometry in sandstone, characterizing brittle failure processes in low-porosity rock deformed under triaxial loading conditions in the laboratory, and analyzing the microstructure of porous ceramic insulations. This paper also discusses thoroughly technical and practical considerations for utilzing this technique. Finally, we describe approaches to extract statistical microgeometric descriptions from volumetric image data, and present results derived from confocal volumetric data sets.

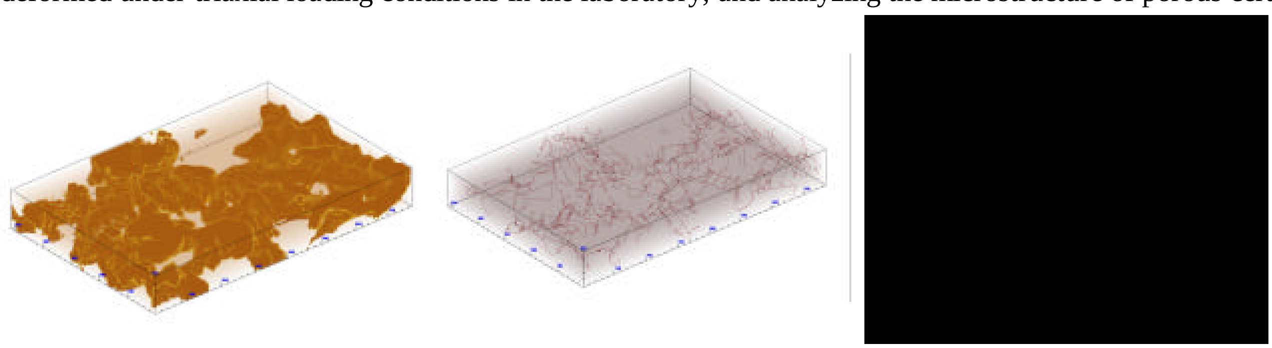

Figure. (Left) 3D volume rendering of pore space in Berea sandstone. The data set is $768 \times 512 \times 101$ voxels in size, with cubic voxels of dimension 1 µm, (Middle) the corresponding medial axis calculated for the pore phase, and (Right) two-point correlation function. The porosity for the image volume (equal to the y-intercept) is 28%, and the specific surface area (inversely proportional to the slope at the origin) is 23 mm^2/mm^3. The upper and lower curves represent one standard deviation. The point at which S_2 reaches an asymptotic values defines a characteristic length for the microstructure (~ 250 µm).

Significance:

Ability to determine both the initial pore structure and its evolution with stress is essential for elucidating the micromechanics of brittle failure, as well as the effects of microstructural damage on other rock properties of practical importance such as permeability and elastic moduli. This paper reviews recent developments, discusses technical and practical considerations, and describes several applications.

Publication:

Fredrich, J.T., "3D imaging of porous media using laser scanning confocal microscopy with application to microscale transport processes," *Phys. Chem. Earth*, 24, 551-561, 1999.